UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION ON FATIGUE PROPERTIES OF NATURAL COMPOSITE CONTAINING COCONUT COIR USING DOE METHOD

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance) with Honours.

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DECLARATION

I hereby, declared this report entitled “Investigation on Fatigue Properties of Natural Composite Containing Coconut Coir Using DOE Method” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) (Hons). The member of the supervisory is as follow:

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(Ts. Mohd Harris Fadhilah bin Zainudin)

ABSTRAK

Projek Sarjana Muda ini menggariskan latar belakang projek "Penyiasatan Sifat Keletihan Komposit Semulajadi Yang Mengandungi Sabut Kelapa Mengunakan Kaedah DOE". Dalam penerapan industri seperti kenderaan, aeroangkasa, aplikasi ketenteraan, bangunan dan pembungkusan, minat dalam bio-komposit berkembang dengan pesat berikutan dengan boleh diperbaharui, kos rendah, mudah terurai, dan biodegradasi, bio-komposit juga semakin meningkat dalam terma penyelidikan asas. Sifat keletihan adalah antara aspek yang paling penting dalam tindak balas mekanikal bahan, dan rintangan keletihan yang mencukupi adalah penting untuk aplikasi praktikal bahan struktur. Ia dikaitkan dengan pengumpulan kerosakan di bawah pemuatan kitaran akhirnya membawa kepada patah. Oleh itu, laporan ini bertujuan untuk menyiasat kesan matriks dan berat diperkukuhkan kepada sifat keletihan menggunakan kaedah DOE. Metodologi kajian dalam projek ini telah dikaji dan dikenal pasti. Proses uji kaji yang telah dilakukan ialah ujian tegangan dan ujian keletihan pada setiap 8 sampel yang berbeza parameter. Setiap sample akan dilakukan ujian sebanyak 3 kali bagi mendapat nilai purata setiap sampel. Sample yang mempunyai parameter PVA yang tinggi menunjukkan kekuatan keletihan yang lebih berbanding dengan sampel yang PVA rendah. Kajian ini diharapkan membantu pengilang dalam menghasilkan produk yang lebih baik dalam industri pembungkusan.

ABSTRACT

This Bachelor Degree Project outlines the background of the project "Investigation on Fatigue Properties of Natural Composite Containing Coconut Coir Using DOE Method". In the application of industries such as automobiles, aerospace, military applications, building and packaging, interest in bio-composites has grown rapidly through renewable, low cost, easy to decompose, and biodegradation, bio-composites are also growing in terms of basic research. Fatigue properties are among the most important aspects of the mechanical response of materials, and adequate fatigue resistance is essential for the practical application of structural materials. It is associated with accumulation of damage under the loading cycle which eventually leads to fracture. Therefore, this report aims to investigate the effects of matrix and weight reinforced on fatigue properties using DOE method. The research methodology in this project has been studied and identified. The testing process was performed on the stress test and the fatigue test on each of the 8 sample parameters. Each sample will be tested 3 times to obtain the average value of each sample. Samples with high PVA parameters showed greater fatigue strength compared to low PVA samples. This study is expected to assist manufacturers in producing better products in the packaging industry.

DEDICATION

Dedicated to my beloved parents, Ishak bin Jaafar and Zalila binti Yahya. Thankyou for your sacrifice, patience and moral support along with me. To my honored supervisor, Ts. Mohd Harris Fadhilah bin Zainudin and all UTeM staff. Thank you to all my friends, for their encouragement and supports through the research. Thank you for your encouragement in preparing this thesis project.

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LIST OF SYMBOLS

%	-	Percentage
σ	-	Stress
ε	-	strain
E	-	Young's Modulus
1	-	Length
m	-	Mass

LIST OF ABBREVIATIONS

DOE	Design of Experiment
PVA	Polyvinyl Alcohol
CSS	Cassava Starch
PLA	Polylactic Acid
DNA	Deoxyribonucleic Acid
RNA	Ribonucleic Acid
ASTM	American Society for Testing and Materials

LIST OF PUBLICATIONS

CHAPTER 1

INTRODUCTION

1.1 Project Background

A bio-composite could be a material shaped by matrix and natural fibers reinforcement. Composite materials are formed by consolidating materials together so as to shape a superior structure. The evolution of composite material started since 4000 B.C when people laminated writing materials from papyrus plant, 1300 B.C with the used of straw bricks by Egyptians and Mesopotamian, 1200 A.D during the invention of composite bows by Mongols. The advantages of forming composite materials can contribute to improving properties such as strength, stiffness, corrosion resistance, and fatigue life (Yusof et al., 2018). Polymers obtained from renewable and non-renewable resources create the matrix phase. The matrix is very significant for protecting the fibers from environmental degradation and mechanical damage, carrying the fibers along and transferring the loads. In the application of industry such as vehicles, railway coach, aerospace, military applications, building and packing, interest in bio-composites is briskly growing. In addition, because of its great advantages such as renewable, low-cost, decomposable and biodegradable, bio-composites are also increasing in terms of basic research.

Plants, animals and biological processes produce natural fibers. It can be used as a component of composite materials and for making products such as paper, felt or fabric it

can also be matted into sheets. Natural fibers such as composite parts for automobiles, can be used for the high-tech application. Natural fibers have advantages such as lower densities, better thermal insulation and less skin irritation in comparison to glass fiber-reinforced composites. All plant fibers contain cellulose as their main component of the structure, while animal fibers consist mainly of protein. Commonly, with the higher performance plant fibers, much higher strengths and stiffness can be achieved than the readily existing animal fibers. An exception is silk, which can be very strong but relatively costly, has lower rigidity and is less readily obtainable. This makes fibers based on plants the most appropriate for use with structural requirements in composites and thus the focus of this review. Plant fiber can also be grown appropriately in many countries and harvested after a not long period of time (Pickering, Efendy, & Le, 2016). Figure 1.1 shows the advantages and disadvantages of natural fibers.

Advantages	Disadvantages
• Low density and high specific strength and stiffness • Fibres are a renewable resource, for which production requires little energy, involves CO_2 absorption, whilst returning oxygen to the environment • Fibres can be produced at lower cost than synthetic fibre • Low hazard manufacturing processes • Low emission of toxic fumes when subjected to heat and during incineration at end of life • Less abrasive damage to processing equipment compared with that for synthetic fibre composites	• Lower durability than for synthetic fibre composites, but can be improved considerably with treatment • High moisture absorption, which results in swelling • Lower strength, in particular impact strength compared to synthetic fibre composites • Greater variability of properties • Lower processing temperatures limiting matrix options

Figure 1.1: Advantages and disadvantages of natural fibers (Pickering, Efendy, & Le, 2016)

One of the most valuable natural fibers made in tropical countries such as Malaysia, Thailand, and Indonesia is coconut coir. In the recent past, there have been many works dedicated to using other natural fibers in composites. Coconut coir is a natural fiber from the coconut husk. In products such as floor mats, doormats, brushes and mattresses, it has been used. Coir is that between the hard inner shell and therefore the outer layer of the coconut, the fibrous material found. In coconut coir, brown coir and white coir, there are two types of coir. Brown coir used in the padding, sacking and horticulture of upholstery. It has a thick, strong and high resistance to abrasion. It is then harvested from unripe coconuts for white coir and used to make finer brushes, string, rope, and nets for fishing. White coir advantage isn't sinking. It can be used on deep water in long lengths without dragging down boats and buoys by adding weight. With thick walls made of cellulose, the individual fiber cells are narrow and hollow. When immature, it is pale, but then it becomes hard and yellowed on their walls as a layer of lignin. Each cell has a diameter of approximately 1 mm and 10 to 20 μm. Typically, fibers are 10 to 30 cm long. It's relatively waterproof in addition to that. A viable worm bedding or worm composting for worms. It is also completely natural, holds water and also provides air pockets in the composting mixture, benefiting the compost mixture and the worms in it.

1.2 Problem Statement

Nowadays, the high demand for non-renewable polymer products have led to destruction of the environment due to the drastic increment of plastic disposal (Simp & Remoto, 2007). The application of biodegradable natural fiber reinforced polymer

composites as a replacement for petroleum-based polymers as well as conservative non-renewable polymer composites has therefore been encouraged by new environmental legislature and consumer pressure. The petroleum resource will reduce over time and it takes hundreds of years to degrade (Yusof et al., 2018). Agricultural-based industries such as coconut industry make positive impact to the economy. However, it also contributes towards pollution in Malaysia. This happens because unused coconut waste is burned down and caused air pollution to occur due to open burning. Therefore it is important to adopt and consider new methods of treating agro-residues in order to achieve sustainable agricultural waste management (Ku, Wang, Pattarachaiyakoop, & Trada, 2011). Bio-composite consists of the matrix and reinforced. There are eco-friendly and the best options compared with petroleum-based composites (Pickering, Efendy, & Le, 2016). The examples of a matrix that have been used such as corn, tapioca, and cassava starch. Then, for the reinforced was coconut coir, rice husk, and bamboo.

Yusof et al., (2018) stated that the usage of polyvinyl alcohol (PVA) in the polymer matrix has been explored for natural fiber composites to enhance polymer's mechanical properties. The tensile strength increased when the contents of PVA increasing. Besides that, the effect of the contents of PVA after increased also makes the impact energy increased after the impact test has been done. In addition, PVA is dependent on humidity, when high the humidity more water is absorbed plus it is a water-soluble synthetic polymer. Saleh, Al Haron, Saleh, & Farag, (2017) stated that fatigue is one of the main reasons for failure in many structural materials. Fatigue occurs when repeated stress was placed until it cause the fracture. Most composites do not display endurance limits and residual properties such as strength and rigidity are often used to evaluate their fatigue properties as cyclic loading leads

to degradation. Besides that, to improve fatigue properties of the composites, high-quality natural fiber is required. High-performance composite polymer materials strengthened with long fibers have a reputation for good fatigue behaviour (Bathias, 2006). Aeronautical applications are successful in replacing metals with composite materials. However, for an engineering point of view, fatigue of composite materials is still an important problem, because its nature is fundamentally different from metal fatigue.

In this research, the factor affect fatigue properties of coconut coir reinforced composite will be investigated by using DOE method or can be defined as a design of experiment. The goal of this method is to approach the material that can materialize the fatigue properties. Coconut coir is a low-cost material. For this research, cassava starch is used as a matrix. The reason for choosing cassava because is most widely growth to produce a sustainable and cheap source of starch globally. Cassava starch (CSS) incorporated with PVA to enhance the physicomechanical properties of the CSS while glycerol is for lubrication and gelatinization (Sin, Rahman, & Salleh, 2011).

1.3 Objective

1) To investigate the effect of matrix and reinforced weight to the fatigue properties using DOE method.

2) To find the highest parameters of fatigue properties from full factorial designs.

1.4 Scope

By following the objectives of this research, the scope of this project is:

1) Use full factorial method as finding the optimum weight of matrix and reinforced composition.

2) Use ASTM D638 to test the fatigue properties.

3) Analysing the highest fatigue strength from varying the parameters of natural composites.